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SOUTHWEST FISHERIES CENTER

REPORT OF ACTIVITIES MAY-JUNE 1987

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COASTAL FISHERIES RESOURCES DIVISION
La Jolla, California

ECOLOGY AND TAXONOMY OF FISHES (CalCOFI)

Preliminary Results of Plankton Work on Groundfish Research Cruise Reported

A research cruise aboard the NOAA Ship *David Starr Jordan* was conducted from January 11 to February 17, 1987, along the central California shelf for evaluating methods of assessing stocks of Dover sole and sablefish.

In addition to bottom trawling operations (see reports by Richard Methot in January-February Report of Activities and John Hunter in this issue), an extensive series of plankton samples was collected using a suite of five samplers. A total of 205 plankton tows was made on three separate legs of the cruise. On the first leg (January 11-25), 25 surface samples were taken with a Manta net, 26 standard CalCOFI bongo samples were taken to 200 m depth, and 18 full water-column samples were taken with a modified bongo net. On the second leg (January 25-February 4) the vertical distribution of Dover sole and sablefish eggs was investigated using a MOCNESS sampler. A series of 20 full water-column tows was made in areas where high spawning activity was reported from trawl catches on the previous leg. Each tow produced samples from nine discrete strata along with associated environmental measurements. On the third leg (February 4-17) 28 Manta and CalBOBL tows were made along with 24 full water-column bongo tows. Also, a 1-m plankton net was attached to the headrope of the trawl, producing 16 non-quantitative plankton samples from near-bottom water.

Manta samples from all cruise legs have now been processed. Although no Dover sole eggs were found on the first leg, they accounted for 1% of the fish eggs found on the second leg and 27% of the fish eggs found on the third leg. Dover sole eggs accounted for 2% of the fish eggs taken in deep bongo tows from the first leg and 4% of the fish eggs from the trawl headrope samples taken during the last leg. Although MOCNESS, standard CalCOFI bongo samples, and some deep bongo samples have yet to be processed, it is apparent that the cruise coincided with the beginning of the spawning season of Dover sole. This is reinforced by results from a group of eight Manta and corresponding standard oblique bongo samples taken aboard the *David Starr Jordan* during April 1987 in the same area of the central California shelf. In these samples Dover sole eggs accounted for 67% of all fish eggs from the Manta tows and 50% of the eggs in the bongo tows.

Sablefish eggs were found in two of the deep bongo tows from the first leg and sablefish larvae were taken in five of the Manta tows from the last leg. This is the first time that eggs

of this species have been collected in the CalCOFI region, since standard CalCOFI plankton tows do not sample the deeper strata of the water column. More exact knowledge of their vertical distribution may be gained from the MOCNESS samples when they are processed. (G. Moser, FTS 893-7129 and R. Charter, FTS 893-7157)

Reproductive Seasonality of Dover Sole Estimated from Historical CalCOFI Samples

Spawning seasonality of Dover sole may be inferred from seasonal variation of larval abundance and is essential for planning assessment cruises. To determine the seasonal variation of larval abundance Fishery Biologists David Ambrose, Barbara MacCall, and Betsy Stevens, and Biological Technician Elaine Acuna reexamined and measured all available larvae in the historical CalCOFI ichthyoplankton collections and found that larvae reach peak abundance from April to July. This confirmed the results published by Ahlstrom and Moser (1975) in CalCOFI Atlas No. 23 (Figure 1). This seasonal pattern is further evident when examining pooled length frequencies of larvae from the CalCOFI collections (Figure 2). The few larvae collected from January to March had a relatively high monthly mean size, with large ranges and standard deviations. In April, the largest number of larvae produced the lowest mean size. Mean size, standard deviation, and range showed a gradual increase throughout the summer months. This pattern is consistent with the April spawning peak suggested by the seasonal incidence and abundance of larvae. (G. Moser, FTS 893-7129)

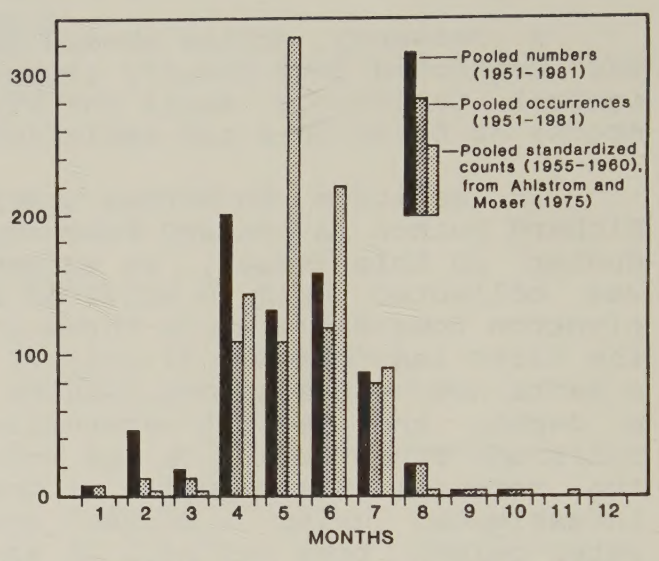


Figure 1. Pooled numbers and occurrences of Dover sole larvae taken in CalCOFI plankton surveys.

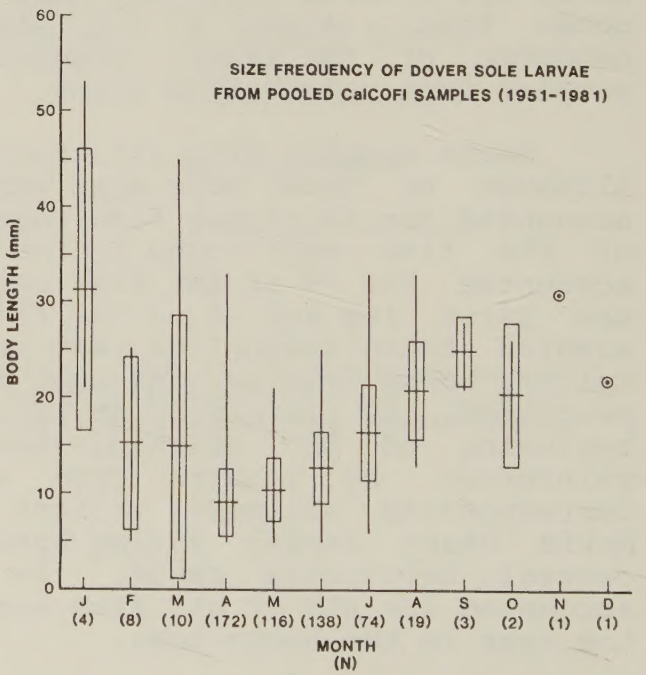


Figure 2. Size frequency of Dover sole larvae from pooled CalCOFI samples (1951-1981).

Euphausiid Predation on Larval Anchovy off the Coast of California

Understanding the processes affecting recruitment of young fish to a fish stock is a fundamental objective in fishery research. Predation is believed to be a major factor affecting survival of young fish and controlling their recruitment. To estimate the portion of northern anchovy egg and larval mortality due to predation by invertebrates, Gail Theilacker, Fishery Biologist, is studying the predatory euphausiids off the coast of California. She is using an ELISPOT immunoassay, which she recently developed (Theilacker et al., 1986, Mar. Ecol. Prog. Ser. 30:127-131) to detect larval anchovy remains in euphausiid stomachs.

The northern anchovy habitat off California was sampled during a California Cooperative Oceanic Fisheries Investigation (CalCOFI) cruise in November 1986 aboard the NOAA Ship *New Horizon* before peak anchovy spawning, and again in March 1987 aboard the NOAA Ship *David Starr Jordan* during peak spawning to determine the incidence of predation by euphausiids. During both the November and March cruises, Theilacker collected euphausiids at night, between 2200 and 0200 when they co-occur with anchovy eggs and larvae in the upper 50 meters of the sea surface. A net allows anchovy eggs and larvae to pass through, precluding biases caused by euphausiids feeding in the net. Collected euphausiids were frozen individually in tubes at 180°C. The following day, Theilacker assayed a subsample (6-10 euphausiids) for presence of anchovy yolk in their stomachs. After the cruise, more animals were assayed at the SWFC laboratory.

On the November CalCOFI cruise, 58 stations were occupied. As expected, anchovy spawning was minimal. Fourteen tows to collect invertebrate predators were taken and only one of these tows was taken inshore where anchovy were spawning (median number eggs and larvae/tow was eight at this station). None of the euphausiids taken in the inshore tow tested positive.

Theilacker assayed 123 euphausiids from the November cruise, and 3 individuals tested positive for anchovy remains. The 3 positive euphausiids were collected at 3 offshore stations, outside of the anchovy spawning area where other fish eggs and larvae (median n = 10/tow) were present. Thus the antibody is cross-reacting with other fish yolk.

On the March CalCOFI cruise, 57 stations were occupied. Anchovy spawning was moderate in the Southern California Bight. Fifteen invertebrate tows were taken and 9 of them corresponded to areas where eggs and yolk-sac larvae were collected. At these positive stations, between 5 and 58% of the euphausiids tested had been eating anchovy, and the percentages roughly correlated with egg and larval abundance.

Theilacker assayed 293 euphausiids from this cruise. Again, as during the November cruise, some positive euphausiids were taken from offshore stations outside the anchovy spawning area. The incidence of other fish eggs and larvae at these offshore stations will be determined.

To estimate daily consumption of larval anchovy by the euphausiid population, information on euphausiid digestion times at *in situ* temperatures is needed. To determine digestion times, Theilacker brought live animals back to the SWFC aquarium from the March cruise. Fifty-five adult euphausiids that had eaten 1 or 2 anchovy larvae were subsequently fed algae for 1 to 6 h. The results of this experiment showed that yolk protein was undetectable in the euphausiid guts after 6 h digestion. There was a 14% probability that digestion was complete after 2 h , 53% after 4 h and 100% after 6 h. The rate of loss appeared to be linear.

To estimate the impact of euphausiid predation on the anchovy population in the California Current, information on total anchovy egg and yolk-sac larval mortality rates and on abundances of adult and juvenile euphausiids is needed. Dr. Nancy C.H. Lo, Mathematical Statistician, has agreed to estimate anchovy egg and larval mortality rates, and Dr. Edward Brinton, Research Biologist at Scripps Institution of Oceanography, has agreed to determine the distribution and size of the euphausiid population for the November 1986 and March 1987 cruises.

This study shows that off California the euphausiid crustacean appears to be a significant predator of larval anchovy. Results of this study should yield an estimate of the importance of invertebrate predation as a source of larval anchovy mortality. (G. Theilacker, FTS 893-7125)

Preliminary Findings on Reproduction of Sablefish Reported

Based on sablefish specimens taken during the cruise on the NOAA Ship *David Starr Jordan* in January 1987, the F/V *American Viking* cruise conducted by the Northwest and Alaska Fisheries Center in October 1986, and port samples taken by the California Department of Fish and Game from November 1986 to February 1987, Fishery Biologist John Hunter has formulated preliminary findings on sablefish reproduction in California from Point Conception to San Francisco Bay. Working with Hunter were Fishery Biologists Roger Leong and Carol Kimbrell, Mathematical Statistician Nancy Lo, Biological Technicians Eric Lynn and Beverly Macewicz, and Biological Aid Mark Drawbridge.

Hunter found that the percentage of females with active ovaries (based on "deck" maturity grades) indicates that peak periods for sablefish reproduction in California are probably between late October and early January. Data are given below for two length classes of females.

Table 1.

Mean collection date	Percentage females with active ovaries			
	Length = 501-600 mm		Length > 600 mm	
	%	N	%	N
Oct. 24 86	39.7	116	61.2	116
Nov. 23 86	41.2	17	-	3
Dec. 04 86	26.7	15	-	5
Jan 17 87	34.9	149	48.9	45
Feb. 11 87	14.2	141	25.4	59

"Deck" maturity grades indicate female length at 50% maturity is about 60 cm fork length. The mean fork length (L) within 50 mm length classes, percent mature (%) and the number (N) per class for collections taken in October-November 1986 were as follows:

Table 2.

L	%	N	L	%	N	L	%	N
410	0	14	550	37.5	48	695	81.8	11
448	0	35	602	62.4	101	800	100.	2
500	4.6	65	646	54.1	61			

The standing stock of advanced oocytes at the beginning of the season (total potential fecundity) was about 104 eggs/gram female weight (preliminary data, which are in general agreement with the literature on sablefish fecundity). Batch fecundity in 13 hydrated females averaged 37 hydrated oocytes per gram female weight (SD = 16). This indicates that a female would spawn about three times to expend all of the advanced oocytes present in the ovary at the beginning of the season. This view is supported by the fact that the hydrated ovaries of 10 of the 13 females contained not only hydrated oocytes, but also other large advanced yolked oocytes destined to be released in one to two subsequent spawnings. It is possible to reconstruct the numbers of eggs released in each successive spawning batch using the numbers of hydrated and nonhydrated advanced oocytes present in the ovary. Such a reconstruction indicates that the average batch size declines with successive spawnings; the average number of eggs in the first spawning may be about 53 eggs/gram, the second about 37, and the last may average about 15 eggs/gram female weight.

The length of sablefish captured in the trawl increased linearly with the trawling depth: the smallest fish was captured at 100 fathoms and the largest at 700 fathoms (Table 3, column 3). No apparent deviation from this strikingly linear relationship existed even at the greatest depth sampled (700 fathoms), indicating that average length of sablefish may continue to increase at depths beyond those sampled.

The strikingly linear increase in the mean length of females with depth is of critical importance from the standpoint of sampling design for the Egg Production Method (EPM). Mean female length increased about 40 mm for each 100 fathoms of depth. More importantly from the standpoint of experimental design for the EPM are the numbers of reproductively active females (defined here as females larger than 600 mm fork length) captured per research trawl haul. Very few such females were captured at depths shallower than 500 fathoms, but from 500 to 700 fathoms about 5 females larger than 600 mm were taken per haul (Table 3, column 7). Thus, to obtain sufficient numbers of active females for EPM fecundity estimates, at least 20 trawls would be needed at depths of 500-700 fathoms at the beginning and at the end of the survey.

Table 3.

Depth (fathoms)	Mean length all fish		Mean length females		Mean number females> 600 mm per trawl	
	N	Mean (mm)	N	Mean (mm)	N	Mean
100	172	373	91	380	4	0
200	48	451	30	460	6	0
300	94	496	50	512	7	0.3
400	65	498	27	517	7	0
500	469	544	233	573	12	5.4
600	239	549	61	603	6	5.7
700	75	604	29	648	6	3.5

The results from the *David Starr Jordan* cruise from January to February indicated that an Egg Production Biomass assessment of sablefish may be practical. Reproductively active adults were sampled in sufficient quantity and, although rare, sablefish eggs were also taken (see report by Geoffrey Moser in this issue). The greatest uncertainty is whether the daily production of eggs is sufficiently high and the period of maximum spawning sufficiently predictable to make an assessment practical. Clearly the rates were too low in January 1987 between Point Conception and San Francisco, and in February 1987 spawning was below the January level. On the other hand, the gonad analysis reported here and data collected by Cailliet and Moser from 1973 to 1974 for Monterey Bay indicate that November-December is a

period of maximum sablefish spawning. Thus, any further evaluation of the practicality of egg production methodology for sablefish biomass assessment will require a November-December cruise. (J. Hunter, FTS 893-7108)

Anchovy Egg Production Time Series Estimated for the Modified CalCOFI Survey Area

In 1985, a new survey pattern for the California Cooperative Oceanic Fisheries Investigation (CalCOFI) program was implemented. The new survey area covers the stations between CalCOFI lines 76.7 (Pt. Buchon) and 93.3 (Del Mar, CA) (Figure 1), which is 40% of the area covered during the full CalCOFI survey years. To assess the anchovy egg production (p_0) in this condensed area, Mathematical Statistician Nancy Lo considered three estimates of anchovy egg production time series for 1980 to 1987: the historical egg production (HEP), a modified HEP (MHEP), and the single equation model (SEM).

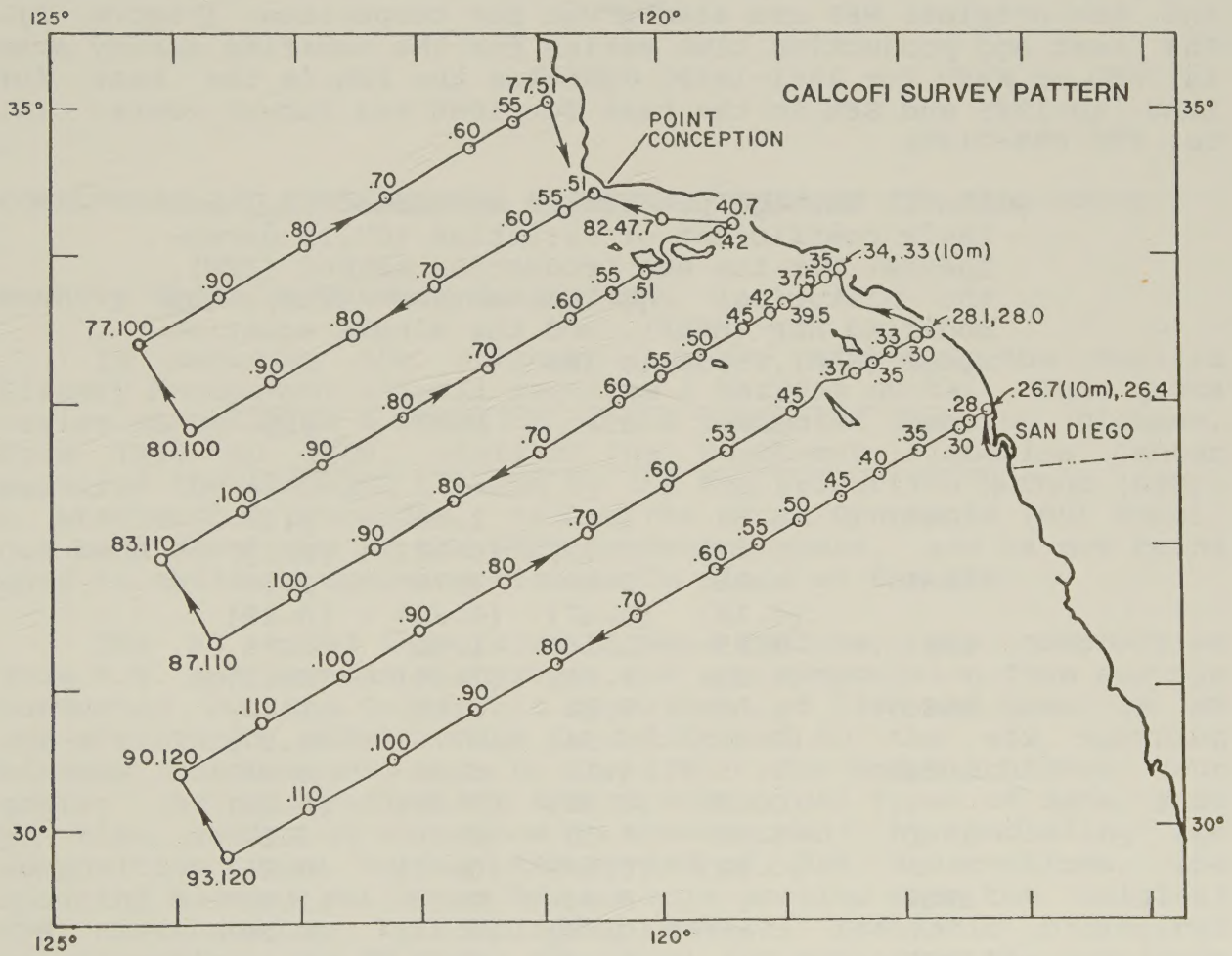


Figure 1.

In formulating the HEP, Lo used the information on egg abundance and sized larvae to estimate daily egg mortality and egg production (Lo, 1985, Fish. Bull., U.S. 83(2):137-150). For the MHEP, she incorporated the egg mortality from the preceding study and the egg and larval data from the modified survey area. The SEM uses data on staged eggs and sized larvae to construct a single mortality curve which allows different forms of mortality for eggs and larvae and produces egg and larval production at age and egg and larval mortality (Lo, 1986, Fish. Bull., U.S. 84(2):395-407).

To evaluate the precision of the three estimates, Lo compared the three estimates for January-April from 1980 to 1987 with the egg production method (EPM), which was implemented from 1980 to 1985 (Table 1). The coefficients of variation for the HEP estimates are between 0.17 and 2.95. The coefficients of variation of the MHEP are between 0.35 and 1.26. With the reduction of sampling effort (about 50 CalVET and 50 Bongo tows), the SEM produces estimates of reasonable precision, with coefficients of variation between 0.13 and 0.30. The coefficients of variation of the EPM estimates (about 1000 CalVET tows) are between 0.12 and 0.26. The time series of HEP, MHEP, and the original HEP are also given for comparison (Figure 2). The best egg production time series for the modified survey area is HEP or MHEP for 1951-1979, whereas the EPM is the best for 1980 to 1985 and SEM is the best for 1986 and future years. (N. Lo, FTS 893-7123)

Table 1. The egg production estimates (P_0) and their coefficient of variation (CV, in parenthesis) for the egg production method (EPM), the historical egg production (HEP), the modified HEP (MHEP), and the single equation model (SEM), 1980 to 1987.

Year	EPM	HEP	MHEP	SEM
1980	5.54	1.49	2.54	1.23
	(0.17)	(0.32)	(0.38)	(0.13)
1981	4.35	2.20	4.74	1.56
	(0.15)	(0.17)	(0.38)	(0.29)
1982	2.85	1.16	1.68	1.78
	(0.23)	(2.95)	(1.26)	(0.15)
1983	3.65	3.18	1.65	1.49
	(0.26)	(0.54)	(0.76)	(0.27)
1984	2.75	6.12	2.56	2.07
	(0.12)	(0.58)	(0.69)	(0.22)
1985	3.58	8.13	5.16	3.21
	(0.12)	(0.54)	(0.42)	(0.26)
1986	-	8.23	7.56	11.84
		(0.54)	(0.44)	(0.29)
1987	-	8.98	7.23	6.00
		(0.35)	(0.35)	(0.13)

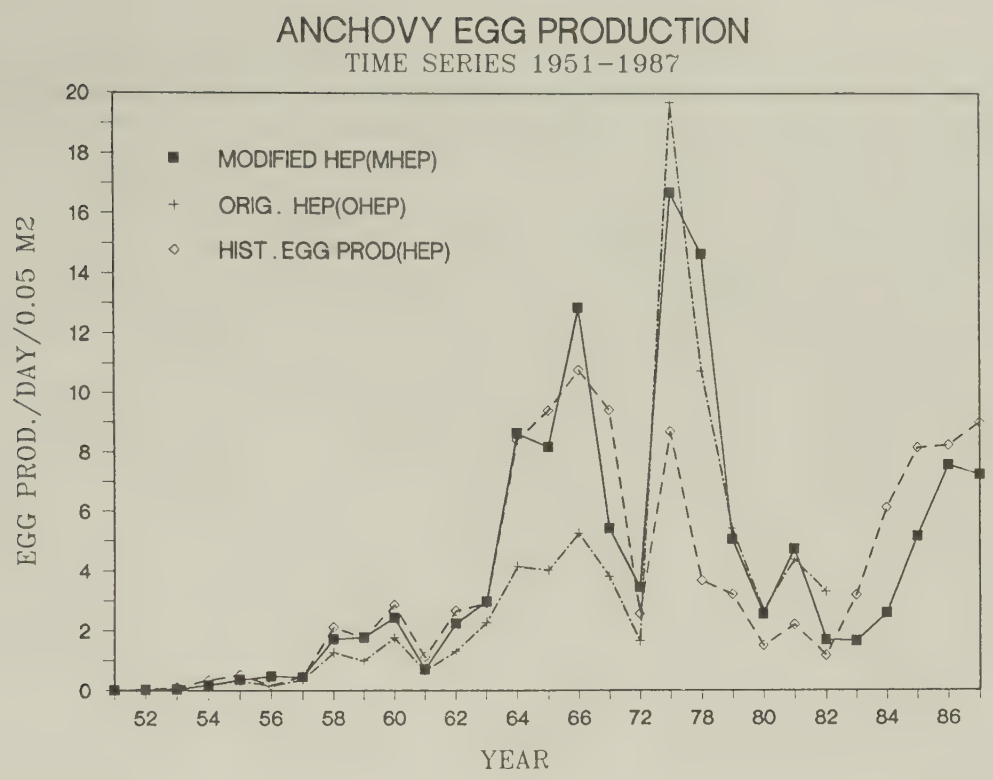


Figure 2.

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Anchovy Spawning Biomass Estimated

In managing the northern anchovy fishery, the Pacific Fishery Management Council requires a harvest quota. This quota varies annually as a function of the estimated spawning biomass. From 1980 to 1985, staff of the Southwest Fisheries Center measured the spawning biomass by the Egg Production Method (EPM). A statistical procedure, called the Stock Synthesis (SS) model, has been developed at the SWFC in recent years, and is now being used to estimate spawning biomass in place of the EPM.

The SS model integrates biomass indices, age composition from U.S. and Mexican fisheries, and age composition from surveys conducted by the California Department of Fish and Game in an age-structured model which is calibrated to the six spawning biomass measurements made by the EPM. The model achieves four goals: by calibrating the EPM to historical types of data, a 35 yr time series of abundance is constructed; by including age composition data during the period of EPM observations, the spawning biomass estimates become more precise than the original EPM observations; by including several realistic biological relationships, the SS model is a tool for exploring the magnitude and consequences of these relationships; and by calibrating current data sources, current spawning biomass can be estimated

without conducting an EPM survey. The model is environmentally sensitive: maturation of young fish is temperature dependent, and relative availability of young fish to the fisheries varies with an index of alongshore transport.

The spawning biomass estimate in 1987 relies on two sources of information. The first source is age composition from the 1986 fishery at Ensenada, Mexico. Monthly landings, age composition and weight at age for the Ensenada fishery were obtained through a contract with Living Marine Resources, Fisheries Research. The second source is egg production, which was measured during the March 1987 California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruise. The Historical Egg Production index, developed by Mathematical Statistician Nancy Lo in 1983, was revised to account for the recent reduction in CalCOFI survey area. Lo reanalyzed the entire CalCOFI time series, selecting only those samples in the new survey area, to develop a modified Historical Egg Production (mHEP) index which provides a context for interpreting present CalCOFI observations (see report by Nancy Lo in this issue).

The spawning biomass in 1987 is estimated to be 1,212,000 mtons (Figure 1). This level is 214% of the mean spawning biomass from 1980 to 1985 and is similar to the peak biomasses observed from 1973 to 1975. The increased biomass was indicated by evidence of good recruitment in 1985 and 1986, and by an mHEP level in 1986-87 which was 242% of the mean mHEP level of 1980 to 1985. Winter temperatures remain warm, 15.0°C during January-February 1987 at the Scripps pier, so a large fraction, 96%, of the age 1 anchovy are estimated to be mature and included in the spawning biomass.

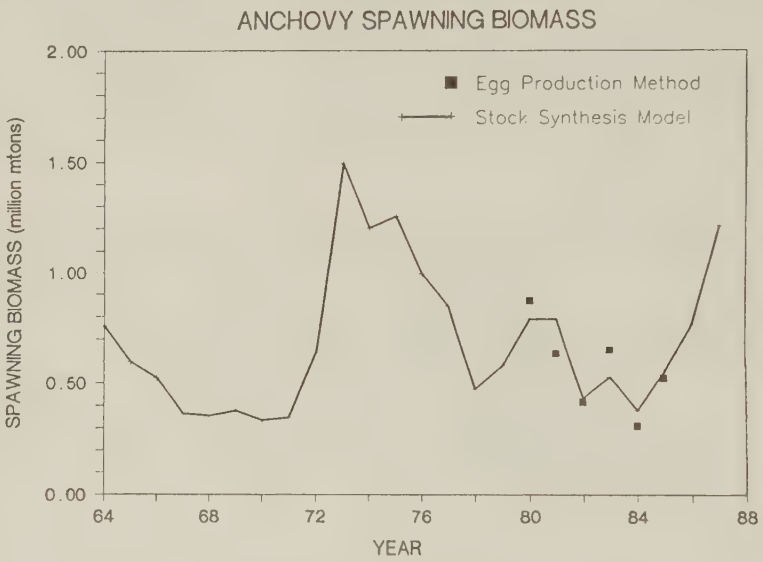


Figure 1. Time series of northern anchovy spawning biomass as estimated by the stock synthesis model.

On the basis of the large spawning biomass, the reduction fishery quota is set at its maximum level, 200,000 mtons, for the 1987-88 fishing season. Recent harvests have been less than the quota. In 1986 the fishery at Ensenada harvested 96,000 mtons and the U.S. fishery harvested less than 100 mtons. (R. Methot, FTS 893-7117)

Report on Status of Coastal Pelagic Fisheries

Cynthia Thomson, Industry Economist, Cheryl Scannell (California Department of Fish and Game), and William Craig (NMFS Southwest Regional Office) have completed an administrative report entitled "Status of the California coastal pelagic fisheries in 1986" (LJ-87-17). The report describes management programs, the commercial harvesting and processing sectors, and recreational fisheries as they relate to the coastal pelagics.

Commercial landings and ex-vessel revenues from the coastal pelagic species in 1981-1986 are summarized in Table 1. The mackerel species (Pacific and jack) are the only coastal pelagics for which landings have been fairly stable over the past few years. Market squid, which all but disappeared from traditional fishing grounds during the El Nino period of the early 1980s, made a dramatic reappearance in 1986. Anchovy landings continued to be low--the fishery has been plagued by adverse market conditions and poor availability. Despite the existence of a healthy export market, bonito landings were also low, largely as a result of poor availability. The California Department of Fish and Game lifted its moratorium on sardines in 1986 and set a 907 mt directed fishery quota, which was exhausted by July 11. Two-thirds of the total catch of sardines was landed incidentally with mackerel; most of the remainder was landed in San Pedro and shipped to Sacramento for use as cut bait in the inland striped bass fishery.

Table 1. Commercial landings and exvessel revenues from California's coastal pelagic species in 1981-1986.

	Landings (metric tons)					
Year	Anchovy	Mackerel	Bonito	Squid	Sardine	Total
1981	51,536	51,631	6,453	22,524	--	132,174
1982	42,050	53,115	2,325	16,240	--	113,730
1983	4,300	51,034	3,404	1,816	--	60,554
1984	2,905	52,947	2,802	564	--	59,218
1985	2,009	43,682	2,367	9,308	--	57,366
1986	1,548	52,878	240	21,280	1,188	77,134

	Exvessel Revenues ($1000's)						
Year	Anchovy	Mackerel	Bonito	Squid	Sardine	Total	Total Defl[1]
1981	3,181	10,813	3,912	5,005	--	22,911	20,904
1982	2,124	10,506	1,087	3,590	--	17,307	14,894
1983	394	9,700	1,373	754	--	12,220	10,124
1984	665	9,574	832	305	--	11,376	9,086
1985	417	8,093	504	3,731	--	12,745	9,817
1986	274	8,590	83	4,882	215	14,044	10,553

[1] Deflated by GNP Implicit Price Deflator (Base Year=1980).

Landings of the coastal pelagic species are normally dominated by vessels based in southern California. In 1986 virtually all of the bonito and 96% of the mackerel landings were made south of Point Arguello. Approximately 70% of the statewide squid landings, 90% of the sardine landings and 22% of the anchovy landings were also made in southern California.

About 15% of total mackerel landings, or 8,000 mt, was canned in 376,000 standard cases, valued at $6.8 million. This represents a 10% increase in both pounds and value from 1985 levels. Although the breakdown between mackerel and other fish is unknown, 6.7 million cases of pet food containing at least 10 pounds of fish per case and valued at $99.7 million was packed in 1986. Most of the squid landed in California is frozen for domestic and export markets, with an insignificant amount finding its way into canned products. Production of processed products from bonito and anchovy was negligible in 1986.

Approximately 4,478 mt of northern anchovy, 100 mt of sardines and 132 mt of squid were caught as live bait in 1986. The lower than average level of anchovy live bait catch can be attributed to a number of factors, including poor availability in nearshore areas and poor albacore fishing in the summer of 1986. Sardines have become an increasingly important component of live bait in recent months.

Due to the high level of spawning biomass, the anchovy reduction quota in the U.S. FCZ is expected to be 140,000 mt in the 1987-88 season. This is the same as the quota set in the previous two seasons and is the maximum amount allowed under the Northern Anchovy Fishery Management Plan. Although there has been some significant upward movement in the fishmeal market price in recent months, the poor availability of anchovy, which has plagued the fishery in recent years, and further recent declines in processing capacity will also have an important bearing on the future of the fishery.

The current biomass for Pacific mackerel is estimated by the California Department of Fish and Game to lie within the range of 342,919 to 907,194 mt. This is considerably higher than the minimum 136,079 mt necessary for an unlimited fishery. Market orders rather than stock conditions will be the factor limiting landings in the 1987-88 season.

The second annual 907 mt directed fishery for sardines was opened on January 1, 1987. The quota was filled rapidly and the directed fishery was closed on April 17 (as compared to the July 11 closure in 1986). The California Department of Fish and Game plans to conduct sea surveys in July/August 1987 again to assess the spawning biomass. (C. Thomson, FTS 893-7115)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

Population of California Sea Lions Assessed

Operations Research Analyst Peter Boveng has completed an assessment of the population of California sea lions. In the assessment he used annual counts of sea lion pups from the four major U. S. rookeries (San Miguel, San Nicolas, Santa Barbara and San Clemente Islands); the counts were made by personnel from the SWFC, the National Marine Mammal Laboratory of the Northwest and Alaska Fisheries Center and Hubbs Sea World Research Institute (Figure 1). The pup counts were used to estimate total population size and population growth rate. The incidental take of the sea lions in commercial fisheries was estimated by California Department of Fish and Game (CDF&G). The pup counts and the mortality estimates were used to estimate the status of the sea lion population relative to the maximum net productivity level (MNPL), which is the lower limit of the range of optimum sustainable population sizes (OSP) in the wording of the U. S. Marine Mammal Protection Act.

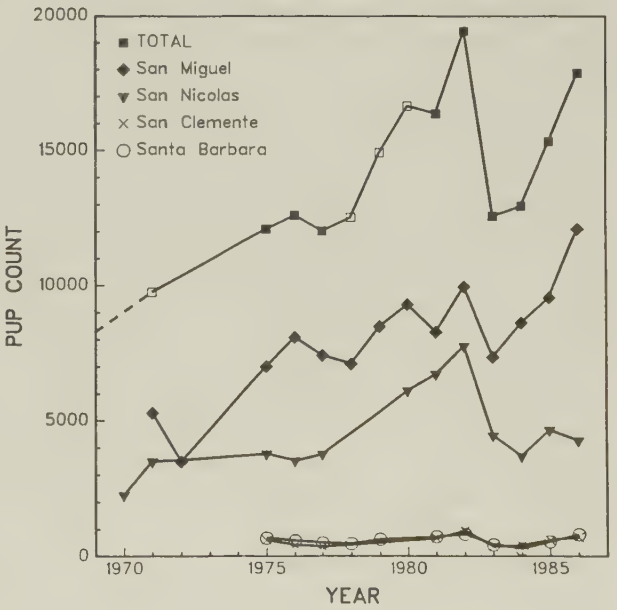


Figure 1. California sea lion pup counts at San Miguel, San Nicolas, San Clemente and Santa Barbara Islands. The total count is shown for years in which counts were available from all four rookeries (solid squares). The open squares represent estimates for years in which a count was made at San Miguel Island but the pup count was estimated by interpolation for one or more of the smaller rookeries.

The total population size, which would correspond to the 1986 count of 17,852 pups (Figure 1), was estimated to be about 83,000 individuals. The population growth rate before 1983, estimated as the slope from regression of the natural-log-transformed pup counts versus year, was about 6.4% annually. The decline of the pup counts in 1983, probably a response to El Nino, complicates estimation of the current growth rate. However, because survival and reproduction during El Nino may have both been reduced, and because the pup counts have not fully recovered to 1982 levels, the present growth rate is probably no greater than the 6.4% estimated prior to 1983.

Dynamic response analysis (DRA), a technique which uses statistical information about the curvature in a population growth curve to infer status relative to the MNPL, was applied to the trajectory of total pup counts (Figure 1). Although the number of data points available was minimal for adequate performance of the DRA, the method indicated that on average, growth between 1975 and 1982 (the most recent interval of suitable length for DRA) was similar to the growth of a population below its MNPL. Furthermore, because incidental fishery mortality was not included in the DRA, and because incidental mortality was probably increasing during the interval, the actual population status was probably lower than the apparent status. The levels of incidental mortality for most years are unknown, but a preliminary estimate for the 1985 fishing season by the CDF&G suggests that about 2,200 were taken in California.

The finding that population status was below MNPL was unexpected. Based on earlier analyses of pup counts at San Miguel Island, which constitutes only about 60% of the total population, the growth rate was believed to be between 4 and 6%, and decreasing as a result of density dependent effects.

Two caveats were included in the interpretation of the assessment results. First, the DRA resulted in a statement about the "average" population status between 1975 and 1982. The current status cannot be inferred from the short time series of data obtained subsequent to El Nino. However, by the same arguments applied above in estimating the current growth rate, the status has probably not changed dramatically from the 1982 level. Secondly, DRA makes status determinations relative to the current MNPL and capacity, which may be different from the MNPL and carrying capacity which were in effect prior to exploitation of sea lions by humans in the 1800's. A recent study by personnel from Hubbs Sea World Research Institute and the National Marine Mammal Laboratory suggested that sea lions may currently be more abundant than they ever were historically because they are no longer subject to predation by large terrestrial carnivores and aboriginal human hunters. The Marine Mammal Protection Act is not specific about whether population status should be measured relative to current or historic carrying capacity. This point may become crucial in the process of renewing general permits to the commercial fishing industry in 1989. (P. Boveng, FTS 893-7173)

Mitochondrial DNA and the Genetic Structure of Spinner Dolphin Stocks and Schools Studied

The relationships between the populations of spinner dolphins (*Stenella longirostris*) killed during purse seining operations for ETP tuna remain puzzling. Understanding the degree of genetic relatedness among these dolphins and making comparisons with other dolphin stocks is important because fishing quotas are established for individual stocks. Four stocks of spinner dolphins in the eastern tropical Pacific Ocean (ETP)--

Costa Rican, eastern, northern whitebelly, and southern whitebelly--have been established based on morphology and, to some extent, distribution.

Fishery Biologists Andrew Dizon and William Perrin have undertaken an analysis of the maternally-inherited mitochondrial DNA (mtDNA) to attempt to clarify details of these relationships. Liver samples from 150 dolphins killed in the fishery were examined with six restriction endonucleases using southern transfer and hybridization with ^{32}P-labeled mtDNA cloned from Commerson's dolphin (*Cephalorhynchus commersonii*), all well-established techniques. Using information determined from the fragments produced by the endonucleases acting on a sample of mtDNA from a single dolphin, estimates of genetic distance were calculated in a pair-wise fashion between all of the dolphins. The genetic distance measurement used was the estimated fraction of nucleotides that was different between one animal's 16,300-nucleotide mtDNA genome and another's. For example, an analysis of 20 eastern and 20 whitebelly samples would yield 190 within-group pairs of genetic distances for each group $(N/2)*(N - 1)$ and 400 between-group pairs of genetic distances ($N_1 \times N_2$). Variance estimates were made with bootstrap methods.

The analyses suggest that the morphologically distinct whitebelly and eastern forms are not genetically distinct at the level dealt with in our analysis of mtDNA. (As with most genetic analyses, application of more endonucleases on more samples may reveal differences. But application of the same six endonucleases on a similar sample size produced an mtDNA phylogeny that was concordant with human races. The implication is that the eastern and whitebelly groups are interbred more than the human races.) The average pair-wise genetic distance between the two groups (0.012) was not significantly different from the average within-group genetic difference of each group (0.011 for easterns and 0.013 for whitebellies). Clearly, sufficient genetic interchange has occurred or is occurring to prevent significant development of mtDNA differences. "Foreign" mtDNA from each group has been exchanged through secondary backcrossing, and recurrent hybridization presumably has occurred after isolating mechanisms responsible for development of the stocks had broken down. Furthermore, it is well established that the mtDNA genome rapidly penetrates leaky genetic barriers more rapidly than the nuclear genome, which is associated with morphological variation. Maintenance of morphologic differences between the eastern and whitebelly groups in the face of this leakage must be the result of fairly intense social or ecological selection for the morphological distinctiveness characterizing eastern and whitebelly spinners.

This situation is in contrast to comparisons of within- and between-group differences of the spotted (*S. attenuata*) and spinner dolphins, two different species. Although the within-group average genetic distance is about the same for both species (0.011 and 0.009), the between-group average species distance is four times higher (0.039).

Analysis of within-group differences of Timor Sea spinner dolphins and ETP dolphins by set reveals another interesting pattern. The 11 Timor Sea dolphins that were studied had been killed in gill net sets within 60 n.mi. of each other and within a time span of 20 days. The mean pair-wise genetic distance within that group is smaller than the within-set values for all the ETP dolphins save one three-animal sample of all identical, common mtDNA type. Furthermore, animals killed in less heavily fished offshore areas in the ETP (cumulative number of sets, about 15,000), in general, have smaller within-set genetic distances than those from the more heavily fished inshore areas (cumulative number of sets, about 50,000). A case could be made that as fishing pressure is increased, schools become genetically more "cosmopolitan" and less "tribal." This could be because purse seine fishing, which involves chases with speedboats and subsequent mortalities and which has been used for several generations, may be disrupting stable school and stock structures. The movements resulting from chase and redistribution of fragmented schools could materially increase the genetic heterogeneity of the observed stocks and produce the result observed between the whitebelly and eastern forms--that is, a lack of concordance between stocks and mtDNA type. There are, of course, other possible explanations of correlation between genetic diversity and history of exploitation. (A. Dizon, FTS 893-7089)

HONOLULU LABORATORY

Honolulu, Hawaii

**David C. Hamm, WPACFIN Manager,
Wins NOAA Bronze Medal**

David C. Hamm, Fishery Biologist and manager of the Western Pacific Fishery Information Network (WPACFIN), has been awarded the NOAA Bronze Medal for his work in developing Pacific-wide fisheries data bases.

> "Your contribution to development and implementation of a computerized data management and collection system is an outstanding accomplishment," wrote NOAA Administrator Anthony J. Calio.

During the past 6 years, Hamm conceived, developed, and implemented a state-of-the-art computerized data management and collection system for linking fisheries information from American Samoa, Guam, Hawaii, the northern Mariana Islands, and a number of areas in the Federated States of Micronesia. WPACFIN now produces annual compilations of fisheries data from the region based on computer data sets maintained at the Honolulu Laboratory. The data are used in fisheries management planning by the Western Pacific Regional Fishery Management Council, for biological research by Honolulu Laboratory scientists, and for a variety of fisheries development and management activities by the territorial offices involved in the project.

Hamm not only initiated WPACFIN as a data network but he also played the central role in determining computer hardware and software needs for the system, training territorial fisheries

staffs in the use of computers, and coordinating fishery information needs among island areas.

Trained as a biologist, Hamm still views computers as servants of science, rather than as end users, and he is vitally interested in the human side of information management. His interest in diving, exotic aquarium fish, and various types of indigenous fishing techniques had facilitated his relationship with Pacific island fisheries staffs. In other words, Hamm has been able to integrate the benefits of the computer age with the sensibilities of island life.

NMFS nationally will now take advantage of Hamm's experience as he undertakes a 2-month rotational assignment at Washington Office Headquarters where he will work in development of current initiatives in Data and Information Management.

MARINE MAMMALS AND ENDANGERED SPECIES PROGRAM

Adult Male Monk Seals Captured from Laysan Island

Five adult male Hawaiian monk seals transported to Honolulu for a behavioral study arrived May 6 aboard the NOAA Ship *Townsend Cromwell*. Captured from Laysan Island, these seals had been identified as participating in several mass attacks, or mobbings, of adult females and immature seals. Attacks by adult male seals have caused the deaths of several seals at Laysan Island, where the population of adult females numbers approximately 50.

The five adult male seals will be used in a study on the feasibility of chemically modifying the aggressive behavior of adult male seals by determining the optimum drug, dosage, and delivery system of a chemical analog to gonadotropin releasing hormone that, when injected into an animal, would depress testosterone levels, thereby decreasing aggressive behavior.

If a suitable procedure is established using these captive seals, an experimental application of the technique on adult male seals at Laysan Island will be conducted to assess the effects of "chemically removing" certain aggressive males from the population. (W. Gilmartin (808) 943-1239)

NMFS Biologist Participates in Cooperative Research Cruise in Northwestern Hawaiian Islands

Dr. Tim Gerrodette and personnel from the U.S. Fish and Wildlife Service (USFWS), the National Wildlife Health Laboratory, and the University of Hawaii conducted studies of seabirds and endangered flora and fauna of the Hawaiian Islands

National Wildlife Refuge. Working from the chartered fishing vessel *Feresa* the group spent from 1 to 8 days at each island or atoll from May 11 to June 11. Gerrodette's task was to count, tag, and measure Hawaiian monk seals and green sea turtles at Nihoa, Necker, Lisianski, Pearl and Hermes, and Midway, locations where no field camps have yet been established this year. Gerrodette reported that the number of monk seal pups born to date is close to the number of pups born in recent years at most islands. Single pups were born on Nihoa and Midway Islands, but apparently none have been born at Necker this year. The cruise also included an experiment on the longevity and fishing action of derelict gill-net fragments. (T. Gerrodette (808) 943-1224)

PELAGIC RESOURCES INVESTIGATION

1987 Hawaiian Skipjack Tuna Fishing Forecasted

A model that predicts the catch of large (>15 lb) aku (skipjack tuna, *Katsuwonus pelamis*) per unit of fishing effort by the Hawaiian domestic pole-and-line fishery has been used to forecast an average of 2,000 lb of large aku per standard day fished in 1987. The availability of large aku is economically more important than the availability of other sizes, and the availability of large aku seems to be more highly correlated with environmental changes.

The forecast is best stated in relative terms because economic factors (especially the closure of the local cannery) have caused radical reductions in the effort expended during a day of fishing. In relative terms, the forecast is the same as the hindcast for 1986 and predicts that more large aku will be available to Hawaii fishermen in 1987 than in 1974 through 1983 (Figure 1).

The model is an update of attempts to predict the total annual catch that started at the Honolulu Laboratory during the 1960's and 1970's. Using data through 1978, Operations Research Analyst Roy Mendelssohn of the Pacific Fisheries Environmental Group reworked and improved this approach in 1986 (Southwest Fisheries Center Administrative Report H-86-13C). Since then, the decline in the capacity of the fishing fleet has made prediction of total catch

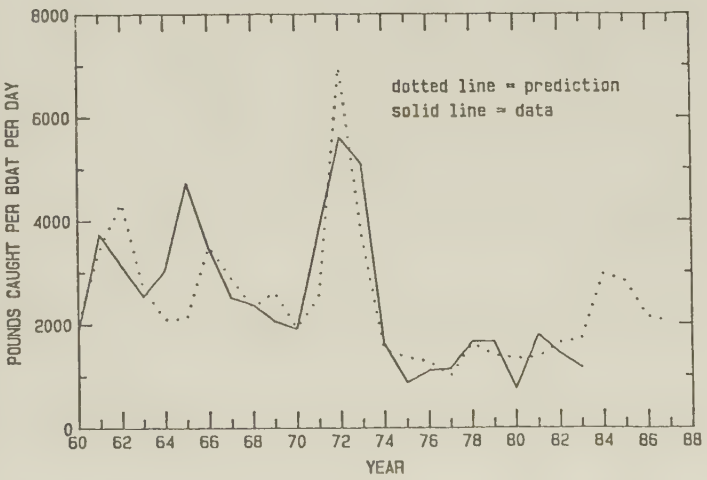


Figure 1. Abundance of large aku (catch per day).

from this model a problem. Recent catch and effort data compiled by Biological Technician Bert S. Kikkawa and Fishery Biologist Robert A. Skillman (NOAA-TM-NMFS-SWFC-72) and data on the size distribution of catches in recent years were used to fit a model that predicts the average annual catch rate of large aku.

The prediction of catch rate is based on the north-south movement of sea-surface temperature isotherms east of the Hawaiian Islands (at long. 140°W) during January through April of the current year and 1 and 4 years previously. High catch rates are predicted when the 20°C sea-surface temperature isotherm is relatively farther north in April than in January for 2 consecutive years. This model explained 68% of the variance in annual catch rates of large aku from 1960 through 1983. The relative proportion of other sizes (<15 lb) of aku in the catch was also predicted from isotherm movements. The forecast for 1987 is that large aku will comprise 48% of the catch, which is again the same as the hindcast for 1986. Assuming the same level of effort this year as was expended last year, the total catch is predicted to be about 2 million lb in 1987.

Time-series data on sea-surface temperature, salinity, and density measured at Koko Head on Oahu were also reexamined in forecasting aku abundance (all sizes): Higher-than-average summer and autumn temperatures were found to precede 5 of the 6 worst years between 1960 and 1983. Higher-than-average temperatures were also observed in the summer and autumn of 1986 (Figure 2).

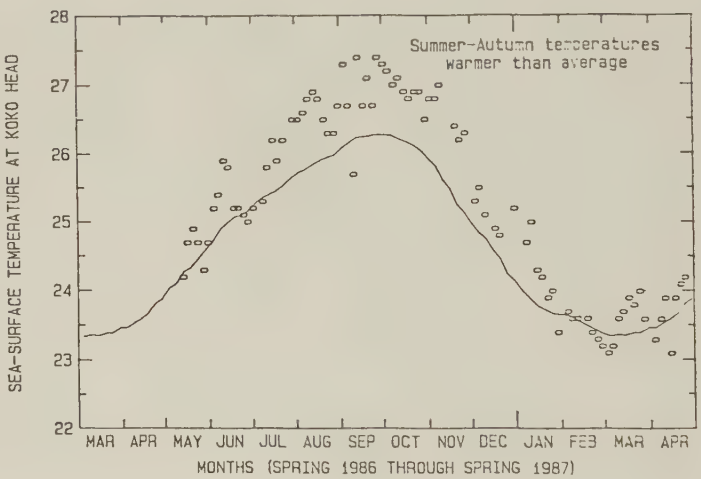


Figure 2. The 1986-87 sea-surface temperatures compared with the long-term average.

In May, a flyer summarizing the forecast and the Koko Head sea-surface temperature data was mailed to the Hawaii tuna industry and other participants in last year's aku workshop and strategic planning sessions held to examine the future of Hawaii's aku (skipjack tuna) industry. (C. Boggs (808) 943-1222)

Computer Program to Summarize Tuna Telemetry Data Completed

Fishery Biologists Randolph K. C. Chang and Dr. Richard W. Brill have developed a computer program to summarize the time a tuna spent at specific depths and specific temperatures from data gathered in the tuna tracking program. This complex program uses XBT (expendable bathythermograph) data and fish's depth data

(taken every 10 sec for up to 48 h) and allows multiple starting and stopping times to be selected and combined for summary. Based on the data analyzed so far, skipjack, yellowfin, and bigeye tunas exhibit great differences in depth distribution and temperature preference, and there are differences in vertical aggregating effect of fish aggregating devices (FAD's). The program will run on an IBM PC or AT and copies are available from Brill. (R. Brill (808) 943-1266)

Research on Burnt Tuna Physiology to Be Published

Fishery Biologist Richard Brill and Peter Hochachka of the University of British Columbia have completed a manuscript on "Autocatalytic pathways to cell death: A new analysis of the tuna burn problem," which has been accepted for publication in *Fish Physiology and Biochemistry* and will appear in Volume 3. The manuscript describes a new model of the etiology of burnt tuna. "Burnt" describes a product quality problem that plagues significant portions of the worldwide catch of large yellowfin and bigeye tunas intended for raw consumption as sashimi. (R. Brill (808) 943-1266)

INSULAR RESOURCES INVESTIGATION

Meters Deployed on Southeast Hancock Seamount to Measure Currents

Participants on the *Townsend Cromwell* cruise during April deployed current meters on SE Hancock Seamount for the first time. This program was a collaborative effort of staff of the Honolulu Laboratory, the Naval Postgraduate School in Monterey, and the Pacific Marine Environmental Laboratory (PMEL) in Seattle. In addition to providing information on the physical oceanography in waters around the seamount, these data will also be useful in determining the patterns of advection of young fish, crustaceans, and other organisms around the seamount.

The two current meter moorings each consisted of three (upper slope mooring) or five (summit mooring) Aanderaa current meters, four steel subsurface floats, an acoustic release, and an approximately 1,500-kg weight attached and spaced from one another through a series of shackles, cable, and chain lengths. Both moorings were set on the northwest side of the seamount and remained for 25-26 days before recovery. This was the first attempt to set and retrieve current meter moorings from the *Townsend Cromwell*, and the procedure went smoothly. Data from the current meters are now being processed at PMEL.

During the same cruise, Research Assistant (and UH graduate student) Christopher D. Wilson surveyed midwater scattering layers associated with the SE Hancock Seamount, using hydroacoustics and midwater trawl operations. Results from three nights of hydroacoustic surveys (using primarily the 38-kHz depth recorder and chromoscope) were related to three nights of Isaacs-Kidd midwater trawl hauls around the seamount. Tows targeted scattering layers present at predetermined depth intervals over and off the summit. Catches consisted of various mesopelagic species including *Maurolicus muelleri* and *Gnathophausia longispina*. Distributional patterns will be related to the water current patterns determined from the current meter moorings. The cruise also included routine longlining and trawling operations for pelagic armorhead, *Pseudopentaceros wheeleri*. (G. Boehlert (808) 943-1234)

Annual Stock Assessment Completed for Bottom Fish FMP

For the annual review of the bottom fishery for the fishery management plan, the Honolulu Laboratory has taken the lead role in developing sections on the biological and economic status of the bottom fishery in Hawaii and in developing a summary of recent research and survey results on bottom fish. In addition, David Hamm, Manager of the Western Pacific Fishery Information Network, has provided information on the fisheries of Guam, American Samoa, and the Northern Mariana Islands.

The fishery management plan (FMP) for bottom fish, which was implemented by the Western Pacific Regional Fishery Management Council in 1986, requires that an annual review of the bottom fishery be completed by the monitoring team, which is made up of a panel of scientists familiar with the fishery and appointed by the Council. This annual review is based on the team's review of a series of sections submitted by various agencies, including the Honolulu Laboratory, the Western Pacific Program Office of the Southwest Region, the Hawaii Department of Aquatic Resources, the Office of Marine and Wildlife Resources in American Samoa, and the Department of Fish and Game in Guam.

For the section of the review on the biological status of the bottom fishery, Fishery Biologist Stephen Ralston and Research Assistant Kurt E. Kawamoto have completed an Administrative Report (Southwest Fisheries Center Administrative Report H-87-7) entitled "An assessment and description of the status of bottom fish stocks in Hawaii." The analysis was based upon data collected from 1984 to 1986 at the Honolulu wholesale fish market. The information obtained represents nearly full coverage of the fishery and includes size structure.

Six species comprise the preponderance of bottom fish landings in Hawaii: opakapaka (*Pristipomoides filamentosus*), onaga (*Etelis coruscans*), ehu (*E. carbunculus*), uku (*Aprion virescens*), hapuupuu (*Epinephelus quernus*), and butaguchi

(*Pseudocaranx dentex*). The first four are snappers, and the last two are a grouper and a jack. Catch statistics indicate the importance of opakapaka in the deep-sea handline fishery, although landings of opakapaka from the Northwestern Hawaiian Islands (NWHI) have declined 16.5% over the last 3 years. Fishermen are now beginning to target on onaga in place of opakapaka in this area and catches of ehu, hapuupuu, and butaguchi in the NWHI have risen as well. In contrast, bottom fish landings in the main Hawaiian Islands (MHI) have remained exceptionally stable (CV = 3.0%).

Size structured yield-per-recruit analyses demonstrate that the MHI fisheries for opakapaka, ehu, and uku are moderately to severely growth-overfished (Figure 3). These species may benefit from minimum size restrictions. By comparison, an increased harvest of onaga in the MHI is suggested, whereas the fishery for hapuupuu appears close to optimal.

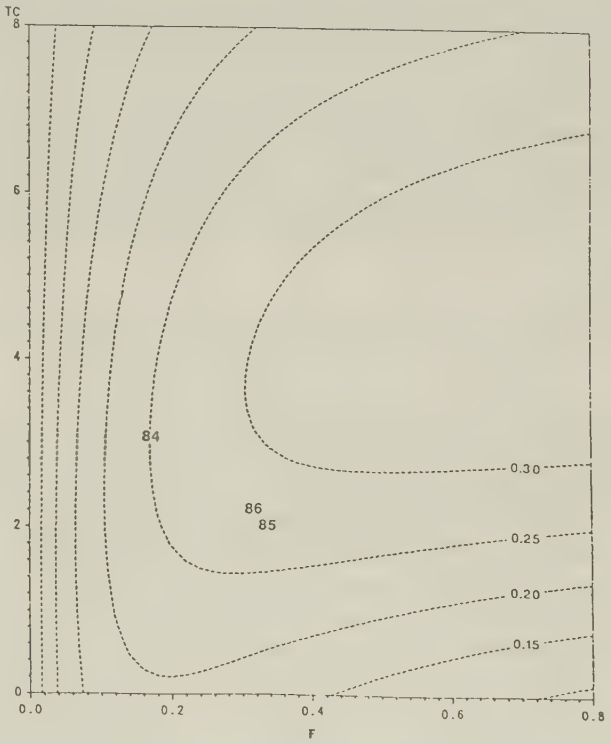


Figure 3. Yield-per-recruit analysis for opakapaka caught in the main Hawaiian Islands. The unit of $\bar{F}$ is per year and the unit of $\bar{t}_c$ is years. Contoured isopleths represent the locus of points corresponding to equal yield per recruit (kilograms). The estimated positions of the fishery during the years 1984, 1985, and 1986 are plotted.

In the NWHI, there is no evidence of growth-overfishing for any of the five species analyzed (opakapaka, onaga, ehu, hapuupuu, and butaguchi). This is likely due to the fishery being in a state of disequilibrium, the result of increasing fishing effort (a 30% increase from 1984 to 1986) and major changes in fishing grounds. In 1986 the fishery for bottom fish in the NWHI shifted almost 300 nmi to the northwest as more distant stocks were increasingly exploited.

Current harvest levels of these fishes in the MHI are believed near maximum sustainable yield (MSY), although much better information about the recreational and the commercial catch that is unaccounted for is necessary before a more accurate assessment can be made. In the NWHI, landings presently exceeded the best available estimate of MSY as bottom fish stocks are presently being "fished up." (S. Ralston (808) 943-1259)

Recreational Fisheries in Hawaii Evaluated

The economic value of recreational fishing in Hawaii was estimated recently during a socio-economic project conducted by Meyer Resources, Inc. under contract to the Honolulu Laboratory (Southwest Fisheries Center Administrative Report H-87-8C). For the project, the staff of Meyer Resources collected information on recreational fishing by interviewing members of recreational fishing clubs, a relatively new approach to economic data development. The project was successful in helping to maintain contact between the Fishery Management Research Program and a number of Hawaii fishing clubs.

Meyer Resources, Inc. found the total nonmarket value of recreational fishing in Hawaii (from boats) to be as much as $239 million from direct expenditures of $24 million. Sales of fish caught outside the full-time commercial fishery is estimated at 10 million lb, and total "resident" (recreational and part-time commercial) catch is estimated at 21 million lb. The techniques used by Meyer Resources, Inc. are experimental in their application to Hawaii, but the results indicate that further investigation of these extensive recreational fisheries is warranted. (S. Pooley (808) 943-1216)

Gary Anders, Visiting Faculty Fellow Completes Economic Research

Dr. Gary Anders of the University of Alaska recently completed a 2-month faculty fellowship in economic research jointly sponsored by NMFS and the East-West Center's Pacific Islands Development Program. Anders, who has considerable experience with native Alaskan claims for fishing rights, prepared a paper on "Property rights issues in a regulated fishery: A case study of Hawaii." The paper was presented at the Western Regional Science Association's annual meeting in Hawaii and at a seminar at the East-West Center, and it will soon be published by the Pacific Islands Development Program.

Examination of native claims from an economic point of view is difficult because of the different values between a discipline whose major emphasis in the United States is toward private property rights and a culture whose rights are frequently held in common. The definition of the problem can be lyrical: Anders begins his paper with the following quotation from a Hawaiian chant:

> A question I ask of you:
> Where is the water of Kane?
> Out there with the floating sun,
> Where the cloud-forms rest on the ocean's breast,
> Uplifting their forms at Nihoa.

(Hawaiian mele translated by N. B. Emerson)

Anders examines the issue of native Hawaiian rights to ocean fishery resources in four parts. The first part discusses a proposal for limited entry in the NWHI. The second provides a general evaluation of the basis for native Hawaiian preference to fisheries resources. The third examines various options for awarding preference, and the fourth considers legislative remedy. Anders concludes that two options (permit auctioning and special use areas) appear to offer high levels of efficiency in meeting native Hawaiian claims with relatively low administrative and enforcement costs. However, he also notes that:

> In the political arena, few, if any, issues are ever permanently resolved. Rather, the character of compromise politics is more like a continuing set of negotiations, with different actors and issues entering the scene and others dropping out, but possibly reappearing albeit in a new costume.

This work is a part of a continuing dialogue in Hawaii over native Hawaiian rights. At present the Council has a special committee investigating such claims in reference to its bottom fish limited entry proposal. (S. Pooley (808) 943-1216)

Council Approves Limited Entry Plan for Bottom Fish

Members of the Western Pacific Regional Fishery Management Council met in Honolulu from June 4 to 5 to discuss a limited entry proposal for the NWHI bottom fishery; the proposal was approved unanimously. Developed by Council staff and consultants with substantial technical input from Honolulu Laboratory staff, the proposal creates a closed zone in the upper reaches of the NWHI where only permitted vessels can fish, and an open zone in the lower reaches where all vessels except permitted vessels can fish.

Also during the meeting, the Council modified the FMP for lobsters (now termed the Crustacean FMP) by approving a minimum legal size for slipper lobster of 5.6-cm tail width and mandating the use of escape panels in all traps. Field work on both measures was conducted at the Honolulu Laboratory.

The Council also voted to recommend against approval of a permit to a drift gill-net fisherman who had applied to the Southwest Region for an experimental permit to fish his gear in the southern regions of the Hawaii extended economic zone (EEZ). The Pelagic Fisheries FMP bans all gill-net fishing in the EEZ except by special permit. Public testimony against the permit was considerable, ranging from environmentalist concerns for the potential impact of the gear on marine mammals and seabirds to sports fishing concerns about the impact of the gear on blue

marlin to commercial fishing operators worried about gear conflict and entanglements. (S. Pooley (808) 943-1216)

DATA MANAGEMENT AND TECHNICAL SERVICES

Hardware Enhancements Improve Processing at Honolulu Laboratory

Staff of the Data Management and Technical Services have been upgrading hardware. A Sysgen DuraPak disk drive, with removable 15-megabyte cartridges, was installed in the Marine Mammals and Endangered Species' IBM PC AT. The drive, which will be used for backup of monk seal data, has several advantages over either a fixed disk or a Bernoulli box: Sysgen is a true hard disk, Sysgen cartridges can hold more data than Bernoulli cartridges, Sysgen cartridges last longer than Bernoulli cartridges, and the drive takes up no desk space (it is internal). Other hardware purchases included an IBM 3.5-inch drive for transferring data between Toshiba 1100+ laptops and IBM PC AT's, 8-mHz clock crystals to increase CPU speed in older IBM PC AT's, an "accelerator" (XCELX 286/287) to speed up processing in newer IBM PC AT's, and a second plotter (Hewlett-Packard Colopro). (D. Tieman (808) 943-1251)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Anchoveta Recruitment off Peru Studied

An exploratory analysis of anchoveta recruitment off Peru has been completed by Jaime Mendo, a visiting scientist from IMARPE in Peru, and Roy Mendelssohn, Operations Research Analyst. In the analysis, they used recently computed estimates of anchoveta recruitment produced by the the Programo Cooperativo Peruana-Aleman de Investigacion Pesquera (PROCOPA) study, which is a joint project of the governments of Germany and Peru and of the International Center for Living Marine Resource Management.

Mendo and Mendelssohn were interested in determining whether recruitment could be predicted a minimum of 3 months ahead using environmental variables as predictors. They used environmental time series for the area off Peru, which had been computed by Chief of the Pacific Fisheries Environmental Group Andrew Bakun, Douglas McLain, and NOAA Corps officer Rusty Brainard. These environmental time series should reflect the oceanographic conditions critical to the anchoveta during the period that Mendo and Mendelssohn were studying. In addition, Mendo had collected and digitized wind data that had been collected every 6 hours from the airports at Callao and Trujillo. Both of these stations are unobstructed and should reflect the wind conditions inshore off of Peru.

The estimated recruitment series (Figure 1) for the Peruvian anchovy (*Engraulis ringens*) shows three distinct periods: low recruitment prior to the start of heavy fishing in 1961-1962; then a period of high and highly variable recruitment; followed by a decline back to earlier levels. The local trend line suggests that recruitment may have started its decline as early as 1969, well before the onset of the 1972-1973 El Niño event. The time series of total biomass exhibits similar behavior, although there is a slight lag.

Figure 1. Time series of monthly anchoveta recruitment and estimated local trend.

A turbulence index was calculated from the Trujillo and Callao wind data as the number of times each month the wind speed remained below 5 meters/second for four straight days. At Callao, the wind was always below the 5 meter/second level, while

at Trujillo the wind was almost always above this level. A cursory examination of the Trujillo series for the nonzero counts showed that the recruitment series was negatively correlated with the turbulence index, and this was true if the recruitment series was lagged 3 to 4 months, the estimated age of the recruits.

The difference between these results and those found for anchovy in the northern hemisphere may be due to the fact that the mixed layer off Peru is deeper, and there is a greater concentration of nutrients. It is unclear what level of turbulence would be required in this region to disperse the nutrients to a point where they become critical to the survival of the eggs of the anchoveta.

The monthly recruitment series was found to be highly autocorrelated (greater than .95 at lag 1), and most of the variance could be explained with an autoregressive model of lags 1, 6, and 12. This model has no mechanistic interpretation and tended to follow rather than predict the sharp rises and drops in the recruitment series. The recruitment series was then divided into six yearly series: February-March recruitment, April-May recruitment, etc. These six series were then analyzed through years and the results compared. Monthly offshore transport and wind speed cubed were calculated from the Trujillo wind data and these data were used as the environmental series. Peak egg production occurs in February-March and again in September, and peak recruitment occurs around June-July. Peak transport tends to occur in September, with another peak around April-May.

For the preliminary analysis, offshore transport for each month was treated as a separate series. Tentative model forms (lags and variables to be included) were selected using the procedures of Tiao and Box (1982, Journal of the American Statistical Assoc., 76:802-816) and the subset regression procedure of Akaike et al. (1979, TIMFAC 78, Computer Science Monograph, No.11, Institute of Statistical Mathematics, Tokyo). Both procedures found recruitment from the preceding 2 years and transport during the September-November period as the key variables for all 6 yearly series. Egg production from the preceding 3-4 months, as well as parent biomass during the same period, was not found to be important predictors of any of the recruitment series.

Mendo and Mendelssohn had reason to believe that the relationships between recruitment and the environment would be nonlinear. They estimated models using the procedure AVAS (Tibshirani, in press, Journal of the American Statistical Association), which empirically estimates transformations of the variables that have certain optimality properties. All six models had r-squared values of .80--that is, about 80% of the variance of the transformed and standardized values of recruitment are explained by the models. The optimal transformation for recruitment was essentially a log function in all cases. To double check the results, parent biomass and egg production, from the preceding 3-4 months, as well as transport

during the time of egg production were forced into the model at various stages of the analysis. Again, these variables never significantly affected the results.

The results of AVAS are seen by displaying a plot of the original series versus the transformed series. For the peak recruitment period June-July, the important predictors were transport in the preceding September and November and recruitment in the preceding 2 years (Figure 2). This result was identical for all six models. The estimated transformations were also similar for all 6 models. The estimated transformations for offshore transport displays a discontinuous behavior in the range where the wind speed is between 6-7 meters/second, where the water becomes hydrodynamically unstable. The estimated transformation for recruitment 2 years earlier suggests a threshold effect--previous recruitment must be higher than a certain level to be good for any 2-month period, but once recruitment is beyond a certain level, it varies randomly around a fixed level.

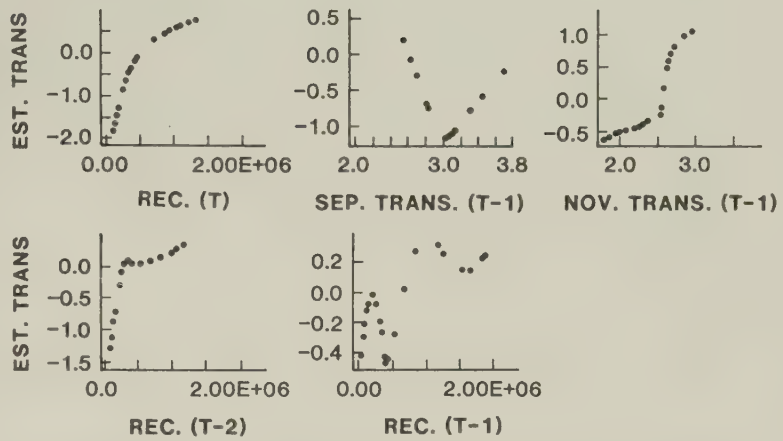


Figure 2. Estimated optimal transformations for predicting June-July recruitment.

The predicted values of this model (Figure 3) are quite good after the early years of limited fishing (before 1960). In particular, the predictions anticipate rather than follow the major declines and rises in the series. Turning points, in general, are well captured by the model after 1960. What is missing is a good mechanistic rationale for the model. It is unclear why transport during September-November should be critical for all months. The 2-year lag in recruitment would seem to reflect parent or spawning biomass, yet these variables were not significant predictors.

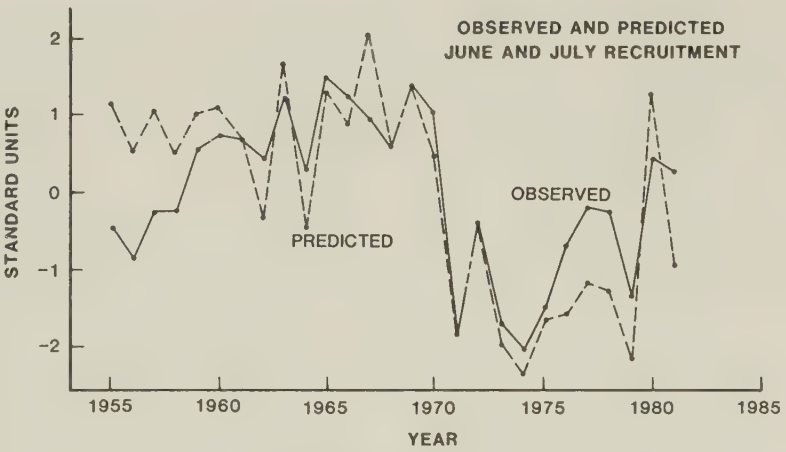


Figure 3. Observed (solid line) and predicted (dashed line) June-July recruitment.

Although this exploratory analysis has raised as many questions as it has answered about the dynamics of anchoveta recruitment, it shows that it appears to be possible to forecast the recruitment estimates that have been produced by the PROCOPA study. If these estimates reflect real changes in recruitment, and a 3 to 8 month lead time in predicting recruitment is useful for management, then it appears that environmental conditions can be used to predict unobserved changes in recruitment and to improve management of important fish stocks. (R. Mendelssohn (408) 646-3311)

PELAGIC FISHERY RESOURCES DIVISION

La Jolla, California

FISHERY MONITORING AND EVALUATION PROGRAM

Statistics of the U.S. Tuna Industry for the First Quarter 1987 Reported

In cooperation with staff of the Southwest Region's Statistics and Market News Service, Fishery Biologists Wesley Parks and Earl Weber of the Fishery and Evaluation Program compile and evaluate data on the United States tuna fishing fleet and United States tuna canneries. They recently completed the following summary for the first quarter of 1987 using data provided by Pat Donley of the Market News Service.

Parks and Weber found that fishing effort during the first quarter (January through March) of 1987 was slightly greater than effort during the first quarter of 1986 (Table 1.) The number of vessels and total capacity both increased about 8%, due primarily to an increase in effort in the eastern Pacific in 1987. However, unlike the first quarter of 1986, there was no effort in the western Atlantic ocean in 1987. There was no effort by U.S. vessels in the Indian Ocean in the first quarter of 1986 or 1987.

Table 1. U.S. purse seine effort by number of vessels and capacity (in short tons) for the first quarter of 1986 and 1987.

Effort	W. Atl.	E. Pac.	W. Pac.	Indian	Total
No. vessels					
Qtr 1, 1987	0	29	23	0	52
Qtr 1, 1986	1	26	23	0	48
Capacity					
Qtr 1, 1987	0	28663	28625	0	57288
Qtr 1, 1986	1200	26180	28175	0	53155

Landings for all species increased in the first quarter of 1987 compared with landings in the first quarter of 1986: yellowfin by 13%, skipjack by 22%, albacore by 331%. The total increase for all species was 17%. The greatest increase in catches occurred in the western Pacific with a 22% increase in total landings despite similar levels of effort in the two periods. Imports of raw frozen tuna to United States canneries decreased by 19% in the first quarter of 1987, compared with deliveries in the first quarter of 1986. By cannery group, receipts increased in American Samoa, California and Hawaii (grouped together for reporting purposes) by 35%, although receipts to Puerto Rico fell 29%.

Parks and Weber compiled information on contract prices for U.S. vessels delivering to U.S. canneries for January 1987. They found that for 1987, U.S. canneries paid from $765 to $780 (U.S. $/short ton) for yellowfin tuna 20 lbs and larger. In 1986, canneries paid from $780 to $800 for yellowfin of that size. For 7.5 to 20 lb skipjack, canneries paid $685 to $700 in January 1987, compared with contract prices of $700 in January 1986. (W. Parks, FTS 893-7074)

NOAA Dive Program at the SWFC Contributes to Research

The NOAA Dive Program was commissioned in 1978 to ensure a safe and professional diving capability that is responsive to all programs within NOAA. NOAA's diving program is the largest of any civilian federal agency with 230 active NOAA divers throughout the many NOAA agencies. The divers are scientists, engineers, NOAA Corps officers, technicians and even a few fishery biologists, who voluntarily use their underwater skills in a wide variety of tasks that include environmental assessments, on-site observations, biological surveys, installation and repair of instruments, inspection and repair of ships, and dive-related research. Divers must maintain a high level of proficiency by performing a minimum of one dive every 2 months and they are required to have an annual physical examination.

The National Marine Fisheries Service has 94 active divers throughout the four Centers and Regions. There are 16 divers at the SWFC, 3 at the Southwest Region, and 2 divers on board the NOAA Ship *David Starr Jordan*.

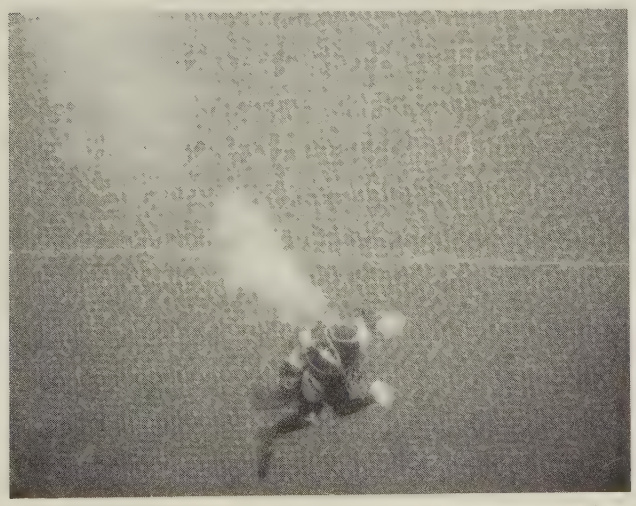
At the La Jolla Laboratory, the diving unit is made up of David Holts, who is also the Unit Diving Supervisor for the La Jolla Laboratory and the Southwest Region, Michael Davis, and Charles Oliver. This unit investigates the efficiency and effectiveness of various fishing gears in the water. The divers investigate the actual fishing depths of drift gill nets and purse seines during experimental and actual fishing operations and they survey halibut spawning grounds. The diving unit has also been a responsive support team for Center programs in emergencies. These divers recently responded to a request from staff of the Coastal Division to recover a bottom trawl lost while sampling off Camp Pendleton. The dive team joined the sampling vessel and were successful in recovering the trawl despite high swells and low visibility. This allowed the survey work to continue and thereby preserved the time series of collections. Dives are also conducted with divers from National Ocean Service stationed on board the *Jordan* for hull inspections, search and recovery of lost gear, and minor maintenance and repairs.

At the Tiburon Laboratory, Tony Chess, Ted Hobson, Brian Jarvis, and Dan Howard make up the dive unit. They support work

of the Groundfish Communities Investigations task by assessing the effects of variations in various environmental parameters of nearshore fish communities, in particular the effects on rockfish recruitment, and habitat selection, and changes in the growth and decline of kelp forests. In assessing the biota in the various habitats, divers visually assess fishes, invertebrates and algae in permanently established belt transects and quadrats. They also collect various biotic components with spears, airlifts, plankton nets, hand dredges and coring tools.

Divers at the Honolulu Laboratory include Mark Ablondi, George Balazs, Barry Choy, Lewis Consiglieri, Alan Everson, John Henderson, John Naughton, Frank Parrish, and David Somerton. They assess the long- and short-term effects of ghost fishing gear and other marine debris, and they observe free drifting gill nets and record the changing net configuration and catch rate. This allows them to evaluate the potential impact of lost and drifting gill nets on marine life. Dives are also conducted to observe and tag green sea turtles in migration and distribution studies. Numerous dives have also been conducted in conjunction with environmental impact assessments and other on-site evaluations in coastal areas.

The group at Terminal Island at the Southwest Region is made up of Bob Hoffman, Dana Seagars, and Ted Beutler. They conduct biological surveys of proposed building sites and for identifying the extended environmental effects of dredging and dumping in both San Diego and Los Angeles Counties. (D. Holts, FTS 893-7186)



(Left) SWFC diver David Holts inspects a drift gill net used in population studies of the Pacific albacore. (Right) Mike Davis, SWFC, Dana Seagars, SWR, Bob Hoffman, SWR, Martin Kinney, Fish and Wildlife Service, and Dick Nitsos, California Department of Fish and Game.

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Vertical Segregation Found in Central California Krill

With assistance from members of the Groundfish Analysis and Groundfish Communities Tasks, Fishery Biologist Susan Smith has been studying the distribution, species composition, and relative abundance of adult euphausiids in the juvenile rockfish sampling area since 1985.

During the rockfish recruitment cruise on the NOAA Ship *David Starr Jordan* from June 2 to 22, Smith helped enumerate, sort, and identify the invertebrate portion of the midwater trawl catches. Night trawls were made at over 40 sampling stations between Bodega Bay and Point Sur, California. Smith's primary emphasis was on euphausiids, which often co-occur with juvenile rockfish in the trawl survey catch.

Both *Thysanoessa spinifera* and *Euphausia pacifica* were commonly taken in June, with *T. spinifera* the most abundant, especially at shelf stations near the Farallon Islands off San Francisco. The highest catches during both sampling sweeps were made at one station located 3.5 miles east of the Southeast Farallon Islands. At this station, 123,000 individuals were taken on June 9, and 127,000 on June 20. Also near the Southeast Farallons, a series of depth-stratified midwater trawl tows was made at one location near a thermal front. Surface tows were made at the warm and cold edges of this front, and depth-stratified tows were made above, through, and below the thermocline. Preliminary results of the analysis of these catches indicate that there is vertical segregation by sex in *Thysanoessa spinifera* (Table 1). Of particular interest is the

Table 1. Sex composition of midwater trawl catches of *Thysanoessa spinifera* made near a thermal front 3 miles southwest of the Southeast Farallon Islands, June 1987.

Trawl fishing location	Wire out (m)	Number of females	Number of males	Percent females
Surface	0	26,712	24,168	52.50
Above thermocline	30	502	288	63.50
At thermocline	85	500	9,508	5.00
Below thermocline	120	457	3,351	12.00
Totals		28,171	37,315	43.00

discovery of a 88-95% male population at and below the thermocline, and the near 50-50 male/female ratio above the thermocline and at the surface. Usually females dominate the trawl catches and dominate predator gut contents examined in late spring and early summer. It is at this time of the year when *T. spinifera* forms breeding swarms that attract a variety of marine predators. (S. Smith, FTS 556-0565)

UNDERUTILIZED RESOURCES INVESTIGATION

Squawfish Utilization Key to Problem of Predation on Juvenile Salmon

Juvenile salmon incur high mortality as they make their way past dams on their seaward migration. The salmon are often disoriented or injured as they are swept through turbulent water just downstream of the dams. At these locations, they fall easy prey to predators, particularly the Sacramento squawfish, a large cyprinid that congregates at these points. In fact, one study revealed that an estimated 12,000 squawfish were concentrated just below Red Bluff Diversion Dam at a time when juvenile salmon were passing through. Squawfish apparently are not major predators of juvenile salmon, except in non-natural situations such as those created by dams.

Agencies that manage salmon at Red Bluff Diversion Dam (U.S. Fish and Wildlife Service, Bureau of Reclamation, California Department of Fish and Game, Southwest Region, NMFS) have studied various means of controlling numbers of squawfish at the dam site. Selective killing of squawfish was possible, but not desirable, as there was considerable opposition to wasteful destruction of the fish. However, it seemed that if squawfish could be used as food, control of their numbers by fishing would not be seriously opposed. Two years ago, at the request of the Southwest Region and the Fish and Wildlife Service, members of the Tiburon Laboratory's Underutilized Fisheries Resources Investigation began studies investigating economical means of catching and marketing squawfish from Red Bluff Diversion Dam.

Initial fishing and marketing trials indicated that the fish could easily be caught selectively with rod and reel and small artificial lures, and that fresh, dead squawfish could be sold for around $0.40 per pound wholesale. Wire fish traps and "jack poles" (no reels) like those used for catching tuna were not successful. One fish wholesaler suggested that live squawfish might bring a price high enough to allow commercial fishermen to catch and sell squawfish economically.

Fishery Biologists Sus Kato and Bill Leet traveled to Red Bluff May 9-11 to carry out fishing and fish handling operations, and to study the feasibility of catching, maintaining,

transporting, and selling live squawfish. Before the trip, they arranged to conduct the study jointly with a potential commercial harvester in Red Bluff and a wholesale fish dealer in Oakland. Two days of fishing with rod and reel demonstrated that squawfish could be caught in large numbers when juvenile salmon are passing through the dam. There had been some concern that alarm substances known to be given off by injured squawfish would make it difficult to carry out successful fishing for sustained periods. Kato and Leet found little abatement in feeding activity until evening, when the fish presumably were not able to see the artificial lures they were using.

Captured squawfish were successfully kept alive in wire enclosures placed in the river. About 50 fish weighing an average of 2.5 to 3 pounds were kept alive, while several larger fish weighing up to 6 pounds each were discarded because they were not marketable as a live product. The fish were transferred to a tank truck provided by the wholesaler and hauled to Oakland on May 11. Surprisingly, only six fish died in transit, despite the rather rough handling they suffered during transfer from the holding cages to the truck. Several other fish died later due to inadequacy of the aquarium system used to hold the fish.

The wholesaler was able to obtain a price of around $1.30 per pound for live fish delivered to retailers, who in turn planned to sell them for around $2.00 per pound. The main use of the fish is likely to be in Chinese restaurants, where it would be used in traditional steamed form, as a cheaper substitute for the more desirable "hardhead" (another cyprinid).

The feasibility of using squawfish commercially will depend on the final fishing and handling costs and the market value, all of which are tied to the quantity of squawfish that are available each time a tank truck makes the round trip between Red Bluff and Oakland. That is, the quantity handled each trip has to be large enough to make it profitable for the fisherman as well as the wholesaler, but at the same time should not be so much as to cause the market price to fall. Such a quantity would probably not be sufficient to solve the predation problem on salmon in the short term, but expansion of the market and increase in fishing pressure may be possible later. More efficient means of catching squawfish are probably available right now, and if the cost of fishing is lowered, it is likely that more fish can be sold.

Potential fishermen and the wholesaler are anxious to start commercial operations. Sport-fishing groups and governmental agencies would also like to see this project carried out. If the logistic problems can be worked out, especially those concerning private use of government land and perhaps equipment, it is possible that next season's run of juvenile salmon making their way to the sea may not have to evade as many squawfish as in the past. (S. Kato, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Preliminary Results of Survey of Pelagic Juvenile Rockfishes Reported

The staff of the Groundfish Analysis Investigation completed the fifth cruise of the annual survey of pelagic juvenile rockfishes. Thirty days of ship time (May 23-June 22, 1987) were used to sample the area from Point Reyes to Cypress Point three times. Replicate sampling will be used to analyze the abundance and distribution of young-of-the-year rockfishes both spatially and temporally. Replicate sampling will help ensure that the evaluation of year-class strength and estimates of recruitment are based on a representative sampling of the population in the study area.

Preliminary data analysis shows that during the first sweep of the sample area, 4,352 pelagic juvenile rockfish were caught in 53 trawls, an average of 82 rockfish/trawl. Twenty-three species were represented primarily by shortbelly rockfish, *Sebastes jordani* (55.5%), squarespot rockfish, *S. hopkinsi* (10.4%), blue rockfish, *S. mystinus* (8.8%), chilipepper, *S. goodei* (6.8%), and widow rockfish *S. entomelas* (6.5%). During the second sweep, 6,972 rockfish were caught in 65 trawls, an average of 107 rockfish/trawl. Twenty-two species were represented primarily by shortbelly rockfish (76%), chilipepper (7.8%), widow rockfish (5.9%), and blue rockfish (2.5%). The third sweep sampled 900 rockfish in 53 trawls, an average of 2 rockfish/trawl. Twenty-three species were represented primarily by shortbelly rockfish (68.7%), chilipepper (7.4%), widow rockfish (5.9%), blue rockfish (4.6%), and squarespot rockfish (4.5%). Analysis of the data is still in progress. (T. Wyllie Echeverria, FTS 556-0565)

FISHERIES INFORMATION SYSTEMS & ADP

National Data Management Committee Meets for Work Session on IT-95 Project

Members of the National Data Management Committee (NDMC) met in Washington, D. C. from June 22-25 to work on the Information Technology 1995 (IT-95) Project. Those attending were Dave Rand, Hoyt Wheeland, and Ray Tillery of the Office of Data and Information Systems, Washington, D.C., Gene Heyerdahl of the Northeast Fisheries Center, Maryanne Treadway of the Souheast Fisheries Center, Darrell Tidwell and Bob Reiman of the Northwest Fisheries Center, David Hamm and Dorothy Roll of the Southwest Fisheries Center, and Fred Brooks, Jim Dudek, and Ted Gaughan (contractors). Representatives from the General Services Administration (GSA), and NOAA ADP Policy Division attended portions of the work sessions to give the committee guidance on contract and procurement regulations.

The objectives of the IT-95 Project are to identify the needs of the NMFS in information technology, and to suggest a national IT configuration and environment that would best serve these needs throughout the 1990s. The key points resulting from the IT-95 work sessions were: based on a consensus from a Board of Director's meeting, the IT-95 procurement is for computer resource power to replace the current operating systems at the regional level; office automation, although covered under the scope of the IT-95 project, will be supported financially at the regional level; facilities management and support will be funded by an increase to base; functional requirements, not hardware requirements, will be specified in the Request for Proposal (RFP); with research data exchange between regional areas minimal at the present time, dedicated lines will be addressed as a telecommunication upgrade when required; an acquisition specialist from GSA's FEDSIM will guide NMFS in writing the RFP; the October 1987 target date for the release of the RFP will be rescheduled.

Twenty-six vendors replied to the Request for Information (RFI) issued in May. Six of the vendors cited the strengths and weaknesses of the RFI and submitted recommendations useful for the RFP. Among the six vendors were DEC, IBM, CRAY, and UNISYS. Representatives of the vendors attended an afternoon meeting with the GSA staff and the NDMC to obtain clarification of NMFS's general information technology requirements. As a result of the meeting, a Request for Comments (RFC), or a draft RFP, will be issued to elicit comments from vendors for incorporation into the final RFP. Dave Hamm will begin writing the RFC while he is on a 2-month rotational assignment in Washington, D.C. Upon Hamm's return to the Honolulu Laboratory in mid-August, Monte Camp from the Southeast Fisheries Center will complete the RFC/RFP. (D. Roll, FTS 893-7057)

STATUS OF PUBLICATIONS

Published

Alvariño, Angeles and Carol A. Kimbrell. 1987. Abundance of zooplankton species in California coastal waters during April 1981, February 1982, March 1984 and March 1985. NOAA-TM-NMFS-SWFC-74, 59 p.

Boehlert, G. W., M. Kusakari, and J. Yamada. 1987. Reproductive mode and energy costs of reproduction in the genus *Sebastes*. *In*: Proceedings of the International Rockfish Symposium, Anchorage, Alaska USA, October 20-22, 1986, pp. 143-152. Univ. Alaska, Alaska Sea Grant Rep. 87-2.

The genus *Sebastes* has historically been considered to be ovoviviparous, with all energy for embryonic development coming from the yolk present at fertilization. Recent studies have shown that embryos of two species receive nutrition in addition to that supplied in the yolk. Embryonic catabolism (estimated from *in vitro* oxygen consumption) required a significant portion of the yolk energy; combined with energy content of the larva at birth, total energy was much greater than the initial egg energy. One can access the accuracy of *in vitro* embryonic oxygen consumption by determining the excess respiration by pregnant females above that of males and immature females. In *Sebastes schlegeli*, this excess oxygen consumption is significant. The additional oxygen consumed by gestating females is greater than that predicted for oxygen consumption of the embryos early in gestation but less later in gestation, suggesting that *in vitro* estimates are approximately 80% high. We discuss the implications of these estimates to earlier calculation of viviparity. Energy taken up through ingestion and absorption of ovarian fluid in the hindgut, however, still confirms viviparity.

Boehlert, G. W., and M. M. Yoklavich. 1987. Long-term cycles of growth in *Sebastes*: Extracting information from otoliths. *In*: Proceedings of the International Rockfish Symposium, Anchorage, Alaska USA, October 20-22, 1986, pp. 197-207. Univ. Alaska, Alaska Sea Grant Rep. 87-2.

Time series of information about fish populations are useful in understanding their natural fluctuations and responses to variation in physical factors. Most time series of fish, however, concern population size, typically estimated from historical catch records. We describe a technique by which growth information can be extracted from otoliths of long-lived species such as *Sebastes* through sectioning and careful measurement. As an example, data from recently collected *Sebastes diploproa* and *S. pinniger* are used to describe growth at ages 1 through 6 during several decades of this century. We describe the technique and its

limitations, and make suggestions for application of the resulting data.

Dyke, Bruce, Jack Hegenauer, Paul Saltman and R. Michael Laurs. 1987. Isolation and characterization of a new zinc-binding protein from albacore tuna plasma. Biochemistry 26:3228-3234.

The protein responsible for sequestering high level of zinc in the plasma of the albacore tuna (*Thunnus alalunga*) has been isolated by sequential chromatography. The glycoprotein has a molecular weight of 66,000. Approximately 8.2% of its amino acid residues are histidines. Equilibrium dialysis experiments show it to bind 3 mol of zinc/mol of protein. The stoichiometric constant for the association of zinc with a binding site containing three histidines was determined to be $10^{9.4}$. This protein is different from albumin and represents a previously uncharacterized zinc transport protein.

Harrison, Craig S., and M. P. Seki. 1987. Trophic relationships among tropical seabirds at the Hawaiian Islands. *In*: J. P. Croxall (ed.), Seabirds--feeding ecology and role in marine ecosystems, Chapter 13, pp. 305-326. Cambridge University Press, England.

Hightower, J. E. and G. D. Grossman. 1987. Optimal policies for rehabilitation of overexploited fish stocks using a deterministic model. Can. J. Fish. Aquat. Sci. 44:803-810.

Traditional fisheries models are of limited use during the transitional period when effort is reduced to permit recovery of an overexploited stock. We used a generalized age-structured model to represent stock dynamics during this transitional period and obtained optimal harvesting policies for three overexploited fish stocks using a first-order gradient procedure. The length of the rehabilitation period was affected by (1) the demographic characteristics of the stock, (2) the historical level of exploitation, and (3) the form of the objective function. When a target stock biomass or spawning stock was specified, rehabilitation was relatively rapid due to the sharp initial reduction in fishing effort. Fishing began earlier in the planning horizon when a target harvest was specified; however, stocks recovered more slowly and fishing effort and harvest did not stabilize at the desired levels as rapidly. Policies for maximizing harvest did not usually result in closure of the fishery; however, fishing effort usually exceeded the desired level and sometimes fluctuated considerably from year to year. Our results should aid in the development of rehabilitation policies tailored to specific fisheries or specific management goals.

Hudgins, L. L., and S. G. Pooley. 1987. Growth and contraction of domestic fisheries: Hawaii's tuna industry in the 1980s. *In*: D. J. Doulman (ed.), Tuna issues and perspectives in the Pacific Islands region, pp. 225-241. East-West Center, Honolulu, 314 p.

Huppert, Daniel D. (Editor). 1987. Limited access alternatives for the Pacific groundfish fishery. NOAA Tech. Rep. NMFS 52, 45 p.

Huppert, Daniel D. 1987. Introduction: Limited access, what is it and why?, pp. 1-5. *In*: Daniel D. Huppert (ed.), Limited access alternatives for the Pacific groundfish fishery. NOAA Tech. Rep. NMFS 52.

Huppert, Daniel D. 1987. Summary and postscript, pp. 37-45. *In*: Daniel D. Huppert (ed.), Limited access alternatives for the Pacific groundfish fishery. NOAA Tech. Rep NMFS 52.

Huppert, Daniel D. and Charles S. Korson. 1987. Profile of the groundfish fishery, pp. 7-11. *In*: Daniel D. Huppert (ed.), Limited access alternatives for the Pacific groundfish fishery. NOAA Tech. Rep. NMFS 52.

Huppert, Daniel D. and Dale Squires. 1987. Potential economic benefits of limited entry, pp. 23-26. *In*: Daniel D. Huppert (ed.), Limited access alternatives for the Pacific groundfish fishery. NOAA Tech. Rep. NMFS 52.

Huppert, Daniel D. and R. Bruce Rettig. 1987. Elements of a limited access program, pp. 13-17. *In*: Daniel D. Huppert (ed.), Limited access alternatives for the Pacific groundfish fishery. NOAA Tech. Rep. NMFS 52.

Kendall, Arthur W., Jr., and William H. Lenarz. 1987. Status of early life history studies of northeast Pacific rockfishes. 1987. *In*: Proceedings of International Rockfish Symposium October 1986 Anchorage, Alaska, pp. 99-128. Univ. Alaska, Alaska Sea Grant Report 87-2.

Rockfishes (*Sebastes* spp.) are highly unusual in that they have internal fertilization of a large number of eggs ($>10^5$) and give birth to planktonic larvae at the first feeding stage. Following the planktonic larval stage, juveniles develop in a variety of habitats, depending on the species. Some remain pelagic for several months, while others become demersal at a small size. Since about 70 species of rockfish occur in the northeast Pacific, identifying the larvae and juveniles is a major problem. Recent studies have greatly enhanced our ability to identify these young stages, which allows us to contemplate using them to address fishery-related problems. Current studies are focused on relating the abundance of larvae and juveniles of rockfish to the adult populations, to measure both adult biomass and recruitment. These studies show promise, but the unusual

biology of the genus limits somewhat the potential of such studies for fishery management purposes.

Lenarz, William H. 1987. A history of California rockfish fisheries. *In*: Proceedings of the International Rockfish Symposium October 1986, Anchorage, Alaska, pp. 35-41. Univ. Alaska, Alaska Sea Grant Rep. 87-2.

Rockfish have been caught off California since prehistoric times. While 60 species are recorded in California waters, less than 20 species make significant contributions to landings by the diverse gears that are used in the fisheries. This paper reviews dynamics in the size and composition of the fishing fleets and landings. Recent events in the fisheries are compared with the history, and important management and research problems of the present are discussed.

Mundy, B. C. 1987. NMFS, Southwest Fisheries Center, Honolulu Laboratory, Honolulu, Hawaii: Insular Resources Investigation. Early Life History Section, Am. Fish. Soc. Newsl. 8(1):12-13.

Perrin, W. F., E. D. Mitchell, J. G. Mead, D. K. Caldwell, M. C. Caldwell, P. J. H. van Bree, and W. H. Dawbin. 1987. Revision of the spotted dolphins, *Stenella* spp. Mar. Mammal Sci. 3(2):99-170.

The taxonomy of the spotted dolphins has been confused. Two apparent species exist, one endemic to the Atlantic and the other pantropical. They have sharply different color patterns and non-overlapping vertebral counts.

However, the holotype specimens for most of the names that have been applied to the spotted dolphins (including *S. attenuata*, *S. frontalis*, *S. plagiodon* and others) are skulls only, with no information on coloration or numbers of vertebrae. The two species overlap in all skull characters; geographical variation in both is pronounced. We used a discriminant analysis based on tooth counts and three skull measurements (standardized to skull width) to identify the type specimens to the two species. We used other criteria for assignment of nominal species for which holotype specimens do not exist. We propose that *Stenella frontalis* (G. Cuv., 1829) be used for the Atlantic endemic species and *Stenella attenuata* (Gray, 1846) for the pantropical species and here redescribe the species. Proposed common names are Atlantic spotted dolphin and pantropical spotted dolphin. *S. frontalis* now includes *Delphinus froenatus* F. Cuv., 1829, *D. doris* Gray, 1846, and *D. plagiodon* Cope, 1866. *S. attenuata* (a *nomen conservandum*) includes *D. velox* G. Cuv., 1829, *D. pseudodelphis* Wiegmann, $\leq$1840, *D. brevimanus* Wagner, 1846, *D. microbrachium* Gray, 1850, *D. albirostratus* Peale, 1848, *Steno capensis* Gray, 1865, *Clymene punctatus* Gray, 1866, *Steno consimilis* Malm, 1871 and *Prodelphinus*

graffmani Lönnberg, 1934. Unidentifiable to either of the two valid species are *D. dubius* G. Cuv., 1812, *D. pernettensis* de Blainville, 1817 (suppressed), *D. malayanus* Lesson, 1826 and *D. Rappii* Reichenbach, 1845; these must remain *incertae sedis*.

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